FRANCE STATUS REPORT

21st JOINT COORDINATING FORUM

INTERNATIONAL ADVANCED

ROBOTICS PROGRAMME

SUMMARY

1. STATUS AND CURRENT ACTIVITY OVERVIEW

1.1. IARP Directions

The current IARP charter with new features such as the creation of Working Groups and cooperation agreements with international Technical Societies emphasizes our role and capacity "to foster international cooperation toward the development of advanced robotic systems able to dispense with human exposure to difficult activities in harsh, demanding or dangerous conditions or environments".

Indeed, front-line novel application domains and scientific and technical issues challenge both robotics researchers as well as social, economical, and political decision makers.

Two synergic work avenues are of paramount importance and call for action.

First, at the level of basic research, we should foster a number of technologies ranging from the design of very novel mechanical devices to the most advanced techniques in machine communication and intelligence.

Second, a broad host of new real-world applications are to be considered and developed. They will provide a technical integrative frame for the emergence of Human Centered Robotics as well as to open an exceptional perspective with a very positive economical and societal impact.

i) Extreme Environments and Field Robotics:

- *Humankind frontier domains*: encompasses applications of intervention robots for hostile and/or remote sites such as planet exploration; sub-sea operation; Earth difficult environments such as Antarctica, volcanoes,…

- *Field-based applications*: mining, tunneling, forestry, agriculture, ...

ii) Public Safety:

- Dangerous waste and artifacts handling, surveillance, safeguarding and public assistance,…

iii) Unmanned Vehicles and Professional Services Robots:

- Drones, cars, professional cleaning, construction and civil work robots, sewer inspection and maintenance, warehousing and inter-modal transportation, professional servicing and catering.

iv) Teleoperation and Networking:

- Remote task execution by users and expert monitoring and assistance: plant maintenance, servicing, medical assistance, health care...

v) Human-Friendly Robotics:

- *Entertainment and educational*: toys, artificial pets, games, educational robots, ...

- *Public oriented services*: public places servicing (airports, museums), hospitals delivery,…

- *Assistive and Personal Robots*: Medicine, Rehabilitation, Household (cleaning, surveillance...), Assistance to the impaired or elderly (companion robots, effective servicing, personal care).

1.2. Current activity and report overview

France research activity in the field of Robotics, in the general context of the domain covered, and the directions set, by IARP, is carried on, as in other developed countries, in every University, Engineering School, Public R&D Institution, and in many corporate organizations.

In this framework, the overall activity encompasses major cooperative research programmes and actions which are pursued both at the national level and via international programmes by National Research organizations such as CNRS (Centre National de Recherche Scientifique), INRIA (Institut National de Recherche en Informatique et en Robotique) and University laboratories together with domain-oriented organizations such as CEA (Commissariat à l"Energie Atomique), EDF (Electricité de France), CNES (Centre National d'Etudes Spatiales), IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer).

This major characteristic was clearly apparent in the large projects, national and international programs, and general activities, included in extensive reports until 1998. France's activity is being pursed in this pattern, and we have chosen since then to focus the yearly reports on a few selected activities. Past reports providing an overall view can be accessed on:

http://www.laas.fr/iarp-france

For the year 2001, the partial activity report comprised four sections encompassing a large spectrum of activities:

- Underwater Robotics,
- Medical Robotics,
- Dependability aspects in Human Friendly Robotics,
- The ROBEA Programme.

The present report pursues the description of these activities, first just by pointing to two specific developments in Underwater Robotics and Medical Robotics, and second largely reporting the important effort carried on in relation to Robot Dependability in Human Environments to conclude with a complete description of the current status of the ROBEA programme.

2. TWO SALIENT INCREMENTAL RESULTS

Underwater Robotics

Current developments and important recent results have led to operational, commercial systems which are reported on Salient examples of real-world operational robotics devices in

http://www.laas.fr/iarp-france/

Medical Robotics

Medical Robotics is one of the major fields considered by IARP and, certainly, one of the fastest growing research efforts in France, as well.

This aspect has been recently stressed at the occasion of SITEF 2002 (October, Toulouse, France) the International Fair of Innovation and Future Technologies, where ENDOXIROB, a robot arm equipped with micro-tools for the laparoscopic surgery composed by 3 arms equipped by miniaturized surgical instruments, has been awarded the SITEF Golden Medal and the Michel Benech Prize for Innovation (ADERMIP).

The project ENDOXIROB is fully described in last year report:

http://www.laas.fr/iarp-france/

3. ROBOT DEPENDABILITY IN HUMAN ENVIRONMENTS

3.1. Context and perspectives

A central direction of research today concerns the field of Human Friendly Robotics also noted as Human Centered Robotics. Central to this large spectrum of novel applications, the domain of Assistive and Personal Robotics, both by its technical aspects and societal and economical impacts, opens a true Grand Challenge.

In the context of IARP, this offers the opportunity to promote a vast spectrum of frontline research themes such as learning, decisional autonomy functionalities and architectures, multi-sensory perception, multi-modal human machine interfaces, … Their embodiment in integrated systems opens a perspective for efficient and realistic development. Moreover, the necessity to have the integrated system operating in contact with humans brings to the frontline of the basic research activity themes that are all too often ignored: safety, reliability, operational robustness, maintainability, … which can be compounded in a more general concept of Dependability.

All around the world growing interest and increased efforts are shown in basic research projects as well as, in several large scale cooperative programmes aiming to demonstrative realizations.

France is actively promoting contributions in this field. A major effort has been devoted to the organization in the frame of IARP and jointly with IEEE/RAS of two dedicated workshops.

3.2. A second WS framework

Workshop objectives

Considering the similarity of interest and objectives, the International Advanced Robotics Programme (IARP) and the IEEE-Robotics and Automation Society (IEEE-RAS) have signed a Memorandum of Understanding agreeing to technical cooperation to foster advances in the fields of Robotics and Automation.

Both organizations recognize the importance, within the broad domain of Human Centered Robotics, of current frontline technical issues and developments in Service, Assistive and Personal Robotics where machines have to closely interact with humans. The R&D directions emphasize in particular the human-machine interaction aspects where the person may be either a non-professional user or a by-stander, or both.

This clearly points out to the critical questions of physical safety and the multiple components of operating robustness. Both aspects can be captured by the concept of Dependability.

Unlike the industrial robotics domain where the work space of machines and humans can be segmented, service and personal robots cannot but have contact interaction. The safety aspect entailed is, of course, already an important challenge addressed to Robotics research.

Still we believe a more difficult and far reaching challenge concerns Operating Robustness. Here, the issues are central to the very concept of "Intelligent" robots.

Indeed Machine Intelligence is a necessity as soon as we consider applications not strictly related to a sole and very simple task. Task diversity in not completely engineered environments and in the presence of non-professional users, implies necessarily significant levels of Robot Autonomy and sophisticated, efficient, robust, friendly machine-intelligence interface.

A first IARP-IEEE/RAS workshop was held in Seoul, Korea, on May 21-22, 2001. The final programme complied with the central technical and operational objectives of the workshop:

- to outline the concepts, methods and tools which define the Robot Dependability domain,
- to assess the state of the art and characterize the main research issues and directions.

A post-workshop report can be accessed on: http://www.laas.fr/rdhe/

The second IARP-IEEE/RAS joint workshop on this broad theme has been organized and hosted by LAAS-CNRS, Toulouse, France, on October 7-8, 2002.

In keeping with the general objective to foster research activity and international cooperation, and to consider mid term and long term market product perspectives, the emphasis is put on main technical issues, research directions and in relevant current work. Application cases highlight specific thematic aspects and bring in state-of-the-art know-how and best practice experience in closely related domains.

Workshop organization

The workshop was organized along sessions on research directions and on specific case studies.

Main research directions:

- Architectures for decisional autonomy
- Specification and verification of robotics software
- Robust user-robot communication and interaction
- Robot design and appearance
- Robust sensing and control
- Fault detection, diagnosis and exception handling
- Evaluation of robot dependability
- Human factors and networked operation

Special case studies were presented by designers and users in the following domains:

- Medical and surgical applications
- Space
- Manufacturing
- Service and assistive robotics

All sessions were set to allow for in-depth open discussion. Two thematic panels completing special sessions further provided room for discussion and assessment. A final general round table concluded the two workshop days. It summarized the workshop contributions and recommendations that will be included in a written workshop report.

The proceedings of the workshop can be assessed on:

http://www.laas.fr/drhe02/preprints.pdf

Workshop sponsorship

An important feature of this workshop concerns the joint sponsorship of the IEEE Robotics and Automation Society and, of course, of IARP. Special worth to mention is the large IARP support since besides France, which hosts the workshop, ten other IARP countries co-sponsor it with the respective country representatives engaged in its direct support: Australia, Canada, France Germany, Italy, Japan, Korea, Russia, Spain, U.K., USA.

4. THE ROBEA PROGRAMME

4.1. Robea: an Interdisciplinary National Program in Robotics

The French CNRS has launched in mid 2001 a national program on Robotics, called "*Robotics and Artificial Entities*" (*Robea: Robotique et Entités Artificielles*)[1]. This interdisciplinary

[1] http://www.laas.fr/robea/

program covers the main research areas of the field, in the department of information sciences and technologies. It also concerns the CNRS departments of engineering sciences, life sciences, and social sciences and humanities. Other national institutes have joined the *Robea* program and/or are contributing to its funding, among which particularly INRIA and the Ministry of Research.

The *Robea* program addresses robotics as the interdisciplinary study, design and integration of sensory-motor and cognitive functions. It is concerned with the integration of these functions within machines that are able to achieve autonomously various tasks in open and changing environments, machines that are able to interact with humans and other machines and able to improve their behavior through learning. Most issues concerned with the study and integration of *perception-decision-action* functions remain relevant and of interest to *Robea* when these cognitive functions are not embodied within a single machine but distributed over a network of sensors, of actuators, of processing and communication equipments.

Consequently the program covers all areas of robotics in a broad sense, and in particular through the issues of their multidisciplinary integration. These are for example:

- Problems for consistent modeling of the environment through multiple heterogeneous representations;
- Problems of perception and motion, of active perception and sensory planning
- Problems of learning sensory-motor functions, procedures, rules and concepts, and problems of actively planning and achieving actions in order to learn.
- Problems of planning and decision making, online, while acting, sensing, communicating and coordinating activities in a distributed interaction; other relevant issues here are those of the architecture of a complex machine, its organization, its bounded rationality, and issues of rational agents in informational systems;

In addition to the main disciplines in Information Sciences and Technologies, *Robea* also covers the following areas:

- Mechanics and material engineering: design of specific actuators, new materials for artificial muscles, mechanical properties of specific systems (flexible, with mechanical loops) or components (legs, arms, hands), bio-mechanical problems in tele-operation, simulation, virtual reality;
- Neurosciences: interaction between different approaches to the study and modeling of sensory-motor and cognitive functions;
- Humanities and social sciences: particularly with respect to the problems of Human-robot interactions through different modalities, for the cooperation, the interactive problem solving and task carrying, and in the study of collective behavior;
- Cognitive sciences: for the study of natural cognition, learning and social behavior, this covers for example the study of emerging properties of individual or collective behavior;
- Medical sciences for the development of new robotics aided techniques of clinical inspection, monitoring and surgery.

The *Robea* program supports collaborative research projects from academic laboratories in France, affiliated to CNRS, to Universities and other public research institutions such as INRIA,

ONERA, CEA, INSERM or IFREMER. The program is open to collaborations with the industry and with foreign partners. Over 200 teams contributed to submissions of projects to *Robea* in 2001 and 2002.

The first call of the program selected 10 projects that are being funded for 2 or 3 years and 5 short projects, funded for one year, eventually renewable. The second call selected 8 projects and 6 short projects.

Robea organizes in the 24th and 25th of October 2002 in Toulouse its first workshop where these projets will present their partial results (see the workshop program in http://www.laas.fr/robea/Activites).

4.2. Projects in progress

The projects covered or submitted to Robea, both in the first program phase 2001 and in the second one completed in 2002, have been presented and discussed in a two-days workshop (October, Toulouse). The presentations can be accessed at the following web address:

http://www.laas.fr/robea/slides-et-textes/Actes-Robea02.pdf

2001 Submitted Projects

Speech and Language Cognitive Robotics: A Speech Endowed Androïd

Partners: ICP; LAPLACE SHARP; Austin University
Duration: 2 years.

Complex Architecture Robots: Design, Performance and Autonomy

Partners: LIRMM; LaRAMA; LASMEA; IRCCyN; INRIA (COPRIN)
Duration: 2 years.

SimBioMan: Biomimetic Simulation of the Manipulation

Partners: LRP; CEA; INSERM 483
Duration: 2 years.

Control of a biped on walking and running gaits

Partners: LMS, Poitiers ; LRP ; LVR, Bourges, *IRCCyN ; LAG ; LGIPM, Metz ; LIRMM*
Duration: 3 years.

AEROB: Land and Aerial Robots for Natural Environments: Vision-Based Environment Modelisation and Safe Navigation

Partners: LAAS ; INRIA (ICARE); CESBIO
Duration: 3 years.

Psikharpax: Towards the Synthesis of an Artificial Rat

Partners: LIP6; LPPA; LIRMM; WANY SA
Duration: 3 years.

Nonholonomic mobile-manipulators control

Partners: INRIA (ICARE); LAAS; LGP-ENIT; GRAVIR
Duration: 3 years.

HR+: Toward a Human-Autonomous Robot Interaction

Partners: LAAS; ICP, Grenoble; GRAVIR
Duration: 3 years.

Motion Control of a Paralyzed Human Leg by Electric Stimulation

Partners: LIRMM; INRIA(BIP); CHU Montpellier
Duration: 2 years.

MARGE: Modelisation, learning and reproduction of the endochirurgical actions

Partners: LIRMM; LRP; CEA-LIST; Hôp. Pitié-Salpétrière
Duration: 2 years.

Modeling, control and localization of hovering systems

Partners: Heudiasyc, UTC; CEMIF-LSC; CREA; INRIA (BIP)

Coordination of human and robot sensory motor tasks by robust cooperation of distributed entities

Partners: LIRMM; Lab. Mouvement et Percetion, Marseille

Dynamic sequencing of multi-sensor based task for mobile-robot complex motion execution

Partners: LAAS; LGP-ENIT Tarbes; CERCO

MAAM project: self-reconfigurable robot

Partners: VALORIA; LRP; LESTER; CEA-LIST, GREYC; LIP6

Evolutionary Robotics: Multi Agent Symbolic Control

Partners: CMAP; INRIA (FRACTAL); LRI; Lab. Mécanique, Rouen

2002 Submitted Projects (partial list)

RoboCoq: Modellig and design of a bird-like robot equipped with stabilized vision

Partners: UMR 8570 CNRS; ESA 7060 CNRS; UVSQ

ROMS: Sugar osmotic-operated medical robot

Partners: TIMC-IMAG; LESIA; PRAXIM; 3S; CHU Grenoble

OMNIBOT: Omni-directional vision for mobile robot control

Partner: LASMEA

COROCOP: Control of Cooperative Planetary Rovers

Partners: CNRS-UMR 6072; INRIA (MAIA); NASA-Ames

AMIRIA: Image movement analysis by impulsional and asynchronous neural nets

Partners: INRIA (Odysee); UMR-5599; Lab for Action Representation and Learning; Tübingen; SpikeNzr Technology

IRON: Robotic implementation of an adaptative neuro controler

Partners: IRIS, AnimatLab